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THIRST

For knowledge of the past and lessons for the future

There is a narrow sidewalk next to US Route 93 at the boundary between Nevada and Arizona. I am not usually inclined to walk alongside four-lane highways, especially those used by 20,000 vehicles daily and in the 43°C heat of a July afternoon. But this took me to the centre of a bridge, 270 metres above the Colorado River and to a perfect view of the Hoover Dam.[1] Constructed almost seventy years ago, this remains a dramatic icon of the human endeavour to control the most precious resource on planet earth: water.

The Hoover Dam was constructed between 1931 and 1936 to protect settlements from floods, to provide irrigation water and to generate hydroelectricity. With its grey concave concrete wall abutting both sides of Boulder Canyon, trapping the deep blue river waters behind to create Lake Mead, it represented a triumph of modern art as much as engineering: an eloquent statement of man's ability to transform the natural world (Photograph 1).

President Franklin Roosevelt had anticipated my emotions precisely in his speech on the morning of 30 September 1935 to dedicate the dam. Standing on his podium in front of 10,000 people he declared that 'This morning I came, I saw and I was conquered, as everyone would be who sees for the first time this great feat of mankind.'[2] The silent gaze of the few others who stood alongside me on that July afternoon in 2011 indicated that they too had been 'conquered'.

The visitor centre at the Hoover Dam explains how it transformed the American West by making possible the growth of Los Angeles, Phoenix, Denver, Salt Lake City and San Diego.[3] By so doing, it also transformed the United States. One might make similar claims for how the Aswan Dam, completed in 1970, has transformed Egypt and

how the Three Gorges Dam, completed in 2009, might do the same for China.[4]

Such dams are merely the most striking statements about a fundamental truth of the modern world: it and we are absolutely dependent upon a managed water supply and hence upon hydraulic engineering. This book asks a simple question: was such dependency also the case for the ancient world, for the civilisations of Mesopotamia, Greece and Rome, for the ancient Maya, Incas and all those other long-lost cultures?

This is not a question merely about the presence or otherwise of dams, aqueducts and reservoirs, a work of tick-box archaeology. *Thirst* is about the driving forces behind the rise and fall of civilisations, the quest for power by ancient kings and the long-term relationship between people, culture and nature. *Thirst* is also about whether the past can provide lessons for the present.

1. WATERSHED

I WAS FREAKING OUT. City bill in hand, I stomped outside to find my husband, James. He was in the garden, his lanky frame hunched over a tomato plant, steadying its metal supporting frame.

Our tomatoes are spectacular—plump, juicy, warm, nectarous treats. They are defying all climatological odds. We live in a high alpine desert. Hailey, Idaho, is located at slightly more than 5,300 feet of elevation. We get exactly sixteen inches of precipitation a year, much of it better for making ski tracks than raising crops. Our growing season stretches a meager seventy-five days between frosts. Word in the gardener's row is that you should wait until all the snow has melted from the east face of Della Mountain before planting your seeds, or so says the ninety-year-old man who lives on Second Avenue. My experience suggests that the last tendrils of snow usually disappear from the slope around Memorial Day—many moons after our fellow gardeners in other parts of the country are gorging on tender young snap peas.

"How can we be using so much water?" I demanded. James stared at me. We had been having this same conversation at

monthly intervals since we started irrigating in the spring—occurring, assuming I could find him, precisely a few moments after I opened our monthly municipal bill.

"Almost 30,000 gallons this month! We can't do this! I can't do this! This is wrong!"

He mumbled something about thirsty trees. I was writhing in distress, blanketed by the guilt of hypocrisy. What I couldn't find the words, or perhaps the pride, to say out loud was, "I am the Water Deva, for Christ's sake!"

In the Buddhist tradition, a *water deva* is a water spirit, connected to all liquids but felt most powerfully in association with streams, rivers, lakes, and the sea. Friends have long called me a "water goddess," and truth be told, I've always felt like one. As a child, I spent untold hours perched on the granite outcrops of New England's coastline, absorbing the nuances of the sea: the way the color of the water shifts toward gray with an oncoming storm; how flotsam gathers on eddy seams; the repetition in wave forms from the largest surges to the tiniest of ripples. I imagined myself a mermaid. The sea compelled me: my education was filled with logarithmic equations describing the arc of a beach form and first-order kinetics equations explaining microbial transformations of chemicals in water. Fittingly, I was born an Aquarian, and my nature shows all the characteristics—fiercely independent, individualistic, artistically and scientifically oriented.

By profession, I have felt compelled to be a Water Keeper. I have spent nearly a decade in the Wood River Valley of Idaho campaigning against water abuses, standing up for the larger interests of the community, and speaking for the fish, the damselflies, and the thirsty elk. I've become a public champion of the cause. I've conducted studies, taught at universities, and published papers. I'm asked to participate on boards. At times this work has put me on the opposite side of the table from developers, where

I've spoken of declining aquifers, faulty water use estimates, and ill-gotten water rights. I've disclosed the ways in which models and calculations, and the assumptions on which they are based, are misguided or misleading. For this work, my experience and academic credentials—including a PhD in environmental engineering from MIT—have been questioned. Regardless, I am unable to sit by silently knowing what I know about the health of our waters and their diminishing reserves.

Yet there I was. We'd used almost 30,000 gallons of water in the past month of August irrigating both an organic garden and a plot of land that covers exactly 0.19 acre, not all of which is vegetated. I ran through the math in my head: say, 10,000 gallons for the first two months of the irrigation season, 30,000 for each of the remaining three grassy-happy months, and a much more stellar 2,500 gallons per month for the rest of the year. Multiply, add, and divide by 365 days to get our average daily water use. I came up with 308 gallons per day. Wait: divide by two to get our per capita consumption. Okay, 154 gallons per person per day. But this was obscuring the shorter-term rate: We had used an average of 1,000 gallons per day this past month, or 500 gallons each.

I exhaled a small sigh of relief. My behavior surpassed that of most slumbering yogis in nearby Ketchum and Sun Valley, who use an average of 767 gallons of water per person per day—according to a recent study by the U.S. Geological Survey—overwatering their expansive flower beds and rambling Kentucky bluegrass lawns. This thought provided only momentary relief, as it is my deeply held belief that 767 gallons per day is an unconscionable use of water. In fact, in all my research I had been unable to locate any other community using this much water. Anywhere. For reference, Las Vegas, the city that couldn't exist were its water not imported from elsewhere, uses a mere 240 gallons per person per day.

A more reasonable comparison would be to benchmark myself against my fellow Americans (mean daily water use: 99 gallons per day) and Idahoans (mean daily water use: 263 gallons per day). I could cut myself some slack, because Idaho's extraordinarily dry climate means additional water is required to cultivate *anything* other than sage. Yet knowing that the average person living in Mozambique subsists on slightly more than one gallon of water per day further demoralized me.

I was torn by cognitive dissonance. My list of rationalizations was long: My husband and I lived low on the food chain. We'd long taken the No Impact Man (and Woman) route, attempting like Colin Beavan (aka No Impact Man)—who chronicled his family's year-long experiment living a zero-waste lifestyle in New York City—to live minimally. We tended and harvested our organic garden to provide for dinner all summer long and well into the fall. We rode bicycles around town as often as possible. We bought locally, notwithstanding the five-and-a-half-dollar price tag for a returnable glass bottle of locally produced organic milk. Our house was relatively small. We were thrift store gurus. I hadn't bought a new couch in a decade. We hiked, we mountain biked, we camped, we river rafted, we skied. We communed with nature. I cried about dead animals, while my husband hunted them for organic, sustainably raised meat. My intellect struggled with my heart. We got it, or at least we both thought we did. Yet somehow, in my personal choices, I was failing the Water Deva test—the quest to live moderately, using water and other resources sustainably.

I couldn't help but feel disappointed and frustrated. Seven years before, when I'd bought the lovely bungalow that would become our home, its south-facing windows had looked out on a small but well-tended perennial cottage-style garden, overflowing

with mounds of purple daisies, pink peonies, and black-eyed Susans. The remainder of the property was covered in traditional Kentucky bluegrass lawn, punctuated by mature aspen to shade the house. Watering the lawn and garden required stringing a snaking web of garden hoses around the property, moving said sprinklers at the appropriate time—and being around to move those sprinklers—and cursing as I tripped over them. Yet I prided myself on using 1,000 to 2,000 gallons of water per month and once calculated my average use at 30 gallons per day.

However, I soon found my peripatetic ways did not lend themselves to gardening success. Departing for backpacking trips into the wilds of southeast Alaska's Wrangell–St. Elias for a month at a time, heading to the beaches on the East Coast, or leaving in the fall for six weeks to teach about sustainable development in the Himalaya left me insufficient time, funds, and capacity to water my lawn, pull weeds, trim tree branches, and rake leaves. The most dramatic evidence of my inattention were the stubbly patches of scorched grass that seemed to be growing in size and appeared to be the first signs of desertification. My aspens, too, were ailing. In a panicked attempt to salvage the trees, I invited an arborist to assess them for me. He told me, "You need to water your trees, you know." No, I didn't know. Since when does anyone water their trees? (Oh, how naïve an East Coaster I was.)

So what did I do? I fell prey to the American Dream, blindly deciding that I would be more successful in managing my property—and avoid hours of dancing with rubber snakes—were I to have an in-ground irrigation system installed. Never mind that it would cost about $8,000. I didn't even consider what it would do to my water use. I was too interested in being free to camp in Alaska to bother wasting a moment's thought. The laziness of the consumer won out.

The irrigation system was installed at the start of one summer. I was pleased to avoid lining up friends to minimally water my lawn while I was away, and I was even more thrilled to be taking to the woods. It wasn't until I returned to town at the end of the summer that my monthly city bill announced the implications of my sloth. I nearly choked—and not because of the cost. Total water use during August: 22,000 gallons. The price, in contrast: $59.

And now, with a husband in the house and a joint interest in seeing the Kentucky bluegrass replaced with edible plants and bushes—and, admittedly, pretty flowers—I saw that our water use had grown even higher. James was confident that, by retrofitting the irrigation system with drip lines to deliver water directly to new plants and crops in our raised beds, he could reduce our consumption. This summer's numbers had proven him wrong. We had struggled with the difficult fact that doing the right thing, the thing we most want to do—convert grass to low-water species, food crops, or otherwise more appropriate vegetation—required time and money. Lots of it. And, like many, we suffered from a dearth of both. So now our Kentucky bluegrass continued to languish *and* we had increased our water use.

I announced emphatically, "This is going to change."

The time had come to embark on a journey to live up to my Water Deva standards. To walk the walk—to swim the swim—I would surmount my personal hypocrisy, revamp the water and energy systems in my home, process my own wastewater onsite, examine the water footprint of the products I consume, and make appropriate choices. My mind was overflowing with ideas about gray water systems, residential-scale digesters, rainwater harvesting systems, low-flow showerheads, permaculture gardens, and wastewater reuse. This would be a methodical study. I would meter and measure, monitor and record. I would document

associated trials and tribulations, revelations, ruminations, facts and figures, philosophy, and more. I would do so with honor and grace. How? I didn't know. When? Soon. Perhaps after a few more toasty showers.

INTRODUCTION

The Evolution of a Water System

Road atlas designers generally divide New York State into two sections. The densely populated southeastern quadrant consumes a page, while the sprawling northern and western sections require two pages. This convention highlights a rather startling reality: with the exception of the Hudson River, the most prominent inland bodies of water in the region that stretches from Long Island to the Catskill Mountains are the reservoirs that serve New York City. North of the city, in Westchester and Putnam Counties, the dozen reservoirs and three controlled lakes of the Croton water system dot the landscape. A hundred miles to the northwest, in the Catskill Mountains, a different picture emerges. In a region laced with rivers, creeks, and streams but bereft of large lakes, six substantial reservoirs dominate their valleys, serene repositories for the snowmelt and water that courses down the hillsides.

The construction and management of New York City's water supply in the twentieth century is the subject of this book. New York City began designing its Catskill Mountains water network in 1905. It completed the Cannonsville Reservoir, the final component of its mountain water system, in the mid-1960s. Damming local streams and two major tributaries of the Delaware River provided New York with an enormous volume of water, enough to meet 90 percent of its needs.[1] *Empire of Water* tells the story of this 90 percent, and the challenge of operating and maintaining one of the world's most extensive water networks.

The regional implications of New York City's waterworks expansion were profound. The flooding of rural communities by enormous reservoirs and the resulting economic dislocation were predictable consequences of waterworks construction. But focusing exclusively on the remaking of the rural landscape obscures the ways in which the desire for water also transformed the suburban and urban recreational and cultural landscape.[2] Exploring developments through this regional prism reveals the diverse and often surprising effects of waterworks expansion

Fig. 1. New York City watershed. New York constructed its water system over the course of 130 years, beginning in Westchester County in 1837 and ultimately ending in the western Catskills in 1967. (Collection, New York City Department of Environmental Protection. Courtesy of the New York City Department of Environmental Protection)

on city, suburb, and countryside. Some communities disappeared; others saw familiar streams altered beyond recognition; others acquired new parks. The construction of the city's water system reconfigured the natural and built environments of southeastern New York State, from Long Island to the headwaters of the Delaware River, 125 miles northwest of the city. New York City's "hydrological

commons," the area affected by its perpetual pursuit of more water, was both much larger and more intricately constructed than historians have recognized.[3]

The eighteenth-century residents of a city notorious for its unsavory water could scarcely have envisioned the elaborate supply and distribution network that the municipal government would construct in the nineteenth and twentieth centuries. Colonial-era New Yorkers relied on hundreds of wells that tapped a network of underground streams. When British troops occupied New York during the Revolutionary War, they destroyed an incipient project to construct a reservoir at the outskirts of the city. (This was the first serious attempt to construct a public water supply.) Independence did not bring an improved water supply. Instead, a combination of rapid population growth and poor sanitation practices led to a steady deterioration of water quality, especially for working-class New Yorkers, who could not afford the high prices charged for more pristine supplies. It was not until the 1830s, in the wake of a ferocious cholera epidemic that killed more than three thousand residents, that New Yorkers voted to build a public water network to convey high-quality supplies from outside the city.[4]

The Croton water system—so named because it drew on the waters of the Croton River and its tributaries—was one of the city's signal accomplishments of the nineteenth century. New York harnessed the labor of Irish immigrants and the capital of America's most prosperous port to build a substantial reservoir and a forty-one-mile aqueduct to carry its waters to hundreds of thousands of citizens.[5] In addition to altering the landscape of northern Westchester County, construction of the Croton system reshaped the city itself. Workers built the elegant High Bridge, which carried the Croton Aqueduct over the Harlem River and into the city. The aqueduct terminated at the Yorkville Receiving Reservoir, which would become a prominent Central Park landmark. From there, water flowed to the distributing reservoir at Murray Hill, a hulking four-story water tank that dominated the surrounding countryside. New Yorkers greeted the arrival of Croton water with unbridled enthusiasm.[6] Municipal officials even commissioned a poem to mark the occasion. George Pope Morris's verse clearly conveyed the joy and wonder of urban dwellers who had long abided inadequate and impure supplies: "Water shouts a glad hosanna! / Bubbles up the earth to bless! / Cheers it like the precious manna / In the barren wilderness."[7]

This enthusiasm proved short-lived. Within a decade, the inability of the water system to keep pace with increasing consumption had become apparent, prompting calls for its expansion. By the 1850s, two patterns that would define New York City's approach to water supply for the next century had emerged: the city would seek pure water from well beyond its borders, and it would engage in a perpetual struggle to secure enough water to meet the demands of the metropolis. Although these trends began in the nineteenth century, they became more pronounced in

the twentieth century, when the scale of New York City's waterworks projects and the level of demand for fresh water reached unprecedented heights. By the time it was finally completed in 1911, the Croton system bore little resemblance to its first incarnation; its original reservoir and aqueduct had been supplanted by larger versions, and its reservoirs and lakes extended over two upstate counties.[8] Generations of engineers and workers had toiled to collect virtually every drop of water from the river and its tributaries, but the Croton's modest yield could not meet the seemingly insatiable demand for water.

Increasing demand for water reflected political and demographic changes. The consolidation of Brooklyn, Manhattan, and other communities into Greater New York in 1898 almost doubled the city's population, placing enormous strains on the water network. Manhattan soon discovered the inadequacy of the water systems it had inherited; locating and tapping new water sources to supply the outer boroughs became one of the first tests of the city's commitment to Brooklyn and the other newly annexed communities. Even as they continued to expand the Croton system, municipal officials recognized the need for a much larger source to accommodate the demands of rapid population growth and increasing per capita water consumption. They again eyed the region north of the city, but this time they looked west of the Hudson, to the dense network of streams that laced the Catskill Mountains, roughly one hundred miles from New York. Like their counterparts in Los Angeles, San Francisco, and Boston, New York's political leaders envisioned a long-distance water delivery system that would draw on rural resources to meet the growing demand of urban dwellers.[9]

The near-continuous process of system expansion from the 1830s to the 1960s shaped and reshaped New York City and its suburbs. The original Croton system relied on reservoirs and pumping stations located within the city to deliver water to urban households. Modernization of the Croton system and the widespread introduction of water from the Catskills beginning in 1917 rendered obsolete most of the water infrastructure within city limits. New York City "recycled" these parcels, greatly enriching the cultural and recreational landscape of the city and its suburbs. Two of Manhattan's most prominent landmarks—the New York Public Library and Central Park's Great Lawn—occupy former reservoir sites. On Long Island, property acquired by Brooklyn to protect its water supply became the nucleus of the island's parkway and state park systems. In Westchester County, the state converted the path of the Old Croton Aqueduct into a linear park, which has become one of the most beloved and utilized recreational resources in suburban New York.[10]

The tendency of historical accounts to focus almost exclusively on the technical aspects of reservoir and aqueduct construction has consigned these urban and suburban by-products of rural waterworks expansion to the realm of anecdote and curiosity. This represents a missed opportunity to connect water supply expansion to

larger themes of public space and the churning of the built environment. By taking a regional perspective on New York City's water system, this book illustrates the wide-ranging and enduring significance of these lesser-known products of waterworks expansion.

In addition to widening the geographical scope of inquiry, I explore developments over a long stretch of time—from the twilight of the nineteenth century to the early years of the twenty-first century. The ecological effects of water development did not end with the completion of a dam. On the contrary, it was only when a reservoir went into service that scientists and watershed residents began to fully appreciate the wide-ranging environmental consequences. Similarly, political tensions between watershed residents and city officials did not disappear with the end of active construction. Frustration with New York City's post-construction watershed policies—its poor record of road maintenance, inconsistent releases of water from its reservoirs back into streams and rivers, restrictions on recreational use of its watershed properties, and frequent challenges of local property tax assessments—explains much of the resentment felt by Catskill residents.[11] The city's management of its hydraulic network often proved just as controversial as its decision to tap Catskill waters in the first place.

This broader approach—exploring the life of a water network, rather than simply its birth—highlights the connections between politics and ecology that lie at the heart of this book. As its title suggests, New York City enjoyed immense autonomy in designing, constructing, and managing its water network. This urban dominance began in 1905, when the city received permission from the state to divert Catskill streams, and continued into the 1960s, when New York completed its last mountain reservoir. Upstate communities surrendered farms, homesteads, and hamlets to the needs of the downstate metropolis. Waterworks development also altered the recreational landscape of the Catskills. Large releases of water from the reservoirs changed the flow, character, and even the temperature of mountain streams. Catskill residents were prohibited from hiking and hunting on thousands of acres of reservoir buffer lands. Until the 1970s, watershed residents won only marginal victories in their attempts to resist New York City's incursions. Their appeals to the state to block reservoir construction amounted to pro forma exercises in free speech; the era of the environmental impact statement had not yet arrived. Those who lost their homes to new reservoirs or saw their businesses fade with the disruption of community living patterns generally received some compensation from the special boards the state created to hear their claims. However, some residents entitled to monetary awards received nothing or next to nothing. In theory, watershed expansion took place under the watchful eye of state and federal authorities charged with balancing the interests of country and city. In practice, the scales of power were rigged in favor of New York City.

The increasing influence of ecology and the erosion of urban political clout led to a gradual but tectonic shift in the balance of power between the city and watershed residents. By the 1970s, the empire that had constructed the vast water network was crumbling. New York City teetered on the edge of bankruptcy, and hundreds of thousands of urban dwellers had fled the city in search of a better life. The state government that intervened to save the city's finances also began to take its environmental responsibilities more seriously, no longer reflexively supporting New York's management of its water system. New York City constructed its water network in the pre-ecological era, but it was compelled to change the way it operated this system to reflect evolving ecological priorities and knowledge. This transformation in environmental governance, dramatic as it was, did not lead to imperial withdrawal. New York City continued to tap the region's streams and rivers to provide water for residents in the city and northern suburbs. Ironically, the emphasis on watershed protection that emerged in the 1990s enmeshed New York City more tightly into the fabric of daily life in the Catskills. But the nature of the relationship between watershed residents and the city had changed dramatically since the 1970s.

The Watershed Memorandum of Agreement, generally known as the MOA, was the most significant evidence of change. The MOA, signed in 1997, balanced the city's desire to minimize human activity in the watershed with the recognition that economic development and expanded recreational opportunities were critical to watershed residents' quality of life. New York secured permission to acquire more land in the areas that supplied its reservoirs. In exchange it agreed to invest tens of millions of dollars into local economies, open up more of its watershed holdings to hunting and hiking, and fund a wide variety of projects to help local farmers, residents, and communities improve water quality. Although the MOA did not eliminate disputes between New York City and watershed communities, it signaled the end of the imperial era. It created new institutional mechanisms designed to forestall serious disputes, and firmly bound the fate of the Catskills to New York City's water supply.[12]

The MOA was based on the concept of ecosystem services—the recognition that preserving natural processes such as pollination and water filtration can be a cost-effective means of achieving environmental goals. A participant in the watershed negotiations likened the plight of Catskill residents to that of Amazon natives: "It behooves the rest of the world to provide some sort of economic alternatives to destroying the rain forest. Well, the same is true up here. The city should provide an economic alternative."[13] The success of the watershed negotiations demonstrated that ecosystem services, a strategy hitherto employed almost exclusively in remote regions, could help protect the economy and ecology of developed areas as well. The New York City watershed agreement is recognized as an international model

of environmental dispute resolution and water management. Experts from around the world have visited the watershed to learn more about its programs, and it has informed the resolution of environmental conflicts in distant regions.[14]

In the American context, the MOA represented an important shift in environmental management. The combination of increasingly sophisticated understanding of ecological processes and more flexible governing regimes gave rise to a more collaborative mode of environmental politics by the late twentieth century. For most of the century, New York City officials maintained a static conception of natural processes; as long as the city continued to draw its water from relatively undeveloped mountain watersheds, its main concern was quantity, not quality. The transition from a command-and-control style of environmental politics to a more cooperative approach that recognized the need to collaborate with watershed residents did not happen overnight. Well into the 1990s, municipal officials clung to the old verities and attempted to unilaterally impose a system of centralized ecological management on its watersheds. Resistance from Catskill residents and the spur of extraordinarily expensive federal water quality statutes were the proximate causes of New York's decision to embrace a new mode of environmental governance. Nonetheless, the arrival of a new breed of environmentally minded city leaders with a more holistic vision of watershed management was critical in forging a collaborative partnership with watershed residents. The ability of these partners to deliver clean water to more than nine million people without sacrificing rural economic vitality ranks as one of the most significant American environmental success stories of the last thirty years.[15]

The evolution of New York City's water supply system reflects significant changes in environmental policy and thought in twentieth-century America. It embodies both the conservationist urge to use nature to meet human needs, and the preservationist impulse to minimize human interference in natural processes. Perhaps most important, it casts the environmental revolution of the final decades of the century in a new light. Most accounts of late twentieth-century American environmental policy emphasize the role of federal statutes and the legal disputes they spawned in establishing the parameters of environmental change and reform.[16] It would be foolhardy to deny the powerful influence of federal regulations. In the case of New York City's water supply, they spurred the negotiations that produced the MOA. But this narrative needs revising. Businesses, environmental organizations, and average citizens did more than fight to restrict or expand the reach of federal regulations in court. As the New York City watershed negotiations reveal, they sometimes worked together to reconcile conflicting social, economic, and environmental goals. Regulations may have established the frame of possible outcomes, but citizens, government officials, and other parties filled in the important details.[17]

Two aspects of the transformation in environmental governance—water conservation and watershed recreation—receive particular attention in this book. They are each important to the environmental history of the water system, and both topics underscore the regional dimensions of water supply expansion. New York bears the dubious distinction of being the last major American city to install water meters in all residences. It did not complete the job until the 1990s, decades after most other cities began using consumption as the basis for water charges. The reluctance to install meters reflected the overall laxity toward water conservation that prevailed until the 1980s. The ability to continually expand the water supply discouraged the development of meaningful conservation policies. Leaking sinks and toilets in Manhattan bore testament to the abundance of Catskill water. The absence of residential metering and low water charges led to some of the highest per capita rates of water consumption in the United States. New Yorkers significantly reduced consumption when droughts threatened to lead to water shortages, but usage shot back up when the rains returned and the reservoirs filled.

The city finally broke this cycle in the 1990s, when it launched the nation's largest toilet replacement program. Despite the first marked increase in New York City's population in decades, overall water usage decreased significantly. Although largely obscured by the MOA, the reduction in water consumption represented a clear break with decades of intransigence and ended all speculation about further expansion of the water system. In 1987, water expert Edwin Clark observed that New York City "has the reputation for the best-engineered and worst-managed water system in the nation."[18] By the late 1990s, this charge no longer rang true. New York was slowly learning how to share regional resources with its neighbors.

One of the most prized resources in the watersheds was recreational space. The development of New York's supply network reshaped recreation on both land and water. Reservoirs provided new fishing opportunities, but water releases from these reservoirs also altered stream conditions, creating challenges for those who sought to swim and fish in the Catskills, the birthplace of American fly-fishing. Conflicts over Catskill waters in the 1970s foreshadowed disputes about recreational access to city-owned lands in the 1990s. To enhance the protection of its water sources, New York City began to purchase land throughout the Catskills, eventually acquiring tens of thousands of acres of mountain holdings. These acquisitions threatened to severely limit access to parcels that had formerly been available for hunting, hiking, and other forms of recreation. Reconciling public health and the desire for recreational access to newly acquired properties loomed as a major challenge.

City and state officials and local residents have worked diligently to expand recreational access to New York's expanding watershed holdings since the signing of the MOA. This collaborative process has revealed areas of common ground

between the needs of the water system and residents' desire to hunt, hike, and explore these lands. The city has expanded hiking and boating opportunities and loosened permit restrictions for using its watershed property. Although conflicts persist over access to particular parcels and policies, New York City has made significant strides in increasing recreational access to its watershed holdings. The change in recreational policy bespeaks a more fundamental shift. Long accustomed to viewing the Catskills as a sparsely populated region immune to larger economic and societal shifts—municipal officials believed that nature would protect water quality as long as people stayed away—New York City gradually adopted a more pragmatic stance that recognized the need to collaborate closely with watershed residents and upgrade technology to ensure the integrity of its water supply.

Water experts describe this more holistic approach as taking the "soft path" to managing water. By partnering with rural residents to protect water supplies and taking aggressive steps to curtail consumption, New York abandoned its long-standing practices of continuous supply expansion and reliance on large-scale technologies to ensure the delivery of high-quality water. The "hard path" to water security that New York City constructed remained in place—it continued to upgrade aqueducts, reservoirs, and treatment systems to meet the needs of its citizens. But protecting water at its source became the centerpiece of the city's approach to managing its sprawling supply network.[19]

The slow transition in environmental governance provides the arc of the narrative and also dictates the form and content of this book. A work of social, political, and environmental history, *Empire of Water* is an exploration of history from the bottom up and the top down. It analyzes developments from the perspective of those building and overseeing the water system and also from the point of view of those who lost their homes and businesses to satisfy New York City's demand for more water. An emphasis on political ecology inevitably highlights the actions of the engineers, lawyers, and politicians who had the power to remake landscapes. As a result, much of the first half of this book centers on the city's own decision-making processes and its legal battles with other states. New York's ability to secure state and federal backing for its waterworks projects was a critical component of its success. The path to Catskill water went through Albany and the United States Supreme Court. The latter chapters focus on management of the system and highlight the efforts of New York City and watershed residents to adjust to the new ecological expectations and financial circumstances that emerged in the 1970s.

Environmental historians are frequently accused of writing declension narratives in which they portray the natural world as idyllic and in balance before human beings came along and cut down trees, built dams, and generally threw nature out of whack. I do not seek to replace one overly simplistic description of

environmental change with another. New York City's water system is a work in progress. The present state of environmental and political equilibrium will not persist forever. Some watershed residents resent New York City's incursions and view the current state of affairs as a violation of their rights. They continue to file lawsuits and closely monitor the city's water operations. Nonetheless, most would acknowledge that they benefit much more from the water system than they did only a few decades before. In an era of intense political friction, the success of the MOA offers hope that a brighter environmental and political future is within reach.

Ever since Peter Minuit's celebrated purchase of Manhattan from the natives for beads and trinkets in 1626, the island has faced challenges of ensuring adequate drinking water. While New York City is obviously surrounded by large rivers, they open on the ocean and are too salty for drinking. The first Europeans to live in Manhattan, the Dutch settlers of New Amsterdam, collected rainwater in cisterns and shallow wells.[1] Most of the settlement's water came from a deep spring-fed, freshwater pond known as the Kalch-Hook, covering seventy acres in lower Manhattan (just east of where Broadway now cuts between Chambers and Canal streets).[2]

The wells in New Amsterdam were private, and none too attractive. As Dr. Benjamin Bullivant described at the time, "[there are] many publique wells enclosed & Covered in ye Streetes . . . [which are] Nasty & unregarded."[3] Although there had been plans in 1660 to build a public well, the famed regional governor, Peter Stuyvesant, refused to approve the funding. This proved remarkably short-sighted, however, when British warships sailed up the Hudson in 1664. The Dutch defense was brief and feeble. Besieged in a fort, the Dutch realized to their chagrin that the fort had no wells and

therefore no water sources. Following a quick surrender, which kept the town's commercial prospects intact, Stuyvesant justified the loss to his employers as not a particularly serious matter since the lack of freshwater on the island made it impossible to defend and easy to regain.

No surprise, then, that one of the first acts of the new British masters, after renaming the city New York, was construction of public wells in the city. Begun in 1667, these would remain a primary source of water for New Yorkers well into the nineteenth century. While the wells were regarded as public works projects, few public monies were actually spent at first. People living on the street where a well had been sited were told to undertake construction on their own. This approach went nowhere, though, with only one brackish well completed. Finally, in 1686, construction of eight wells got underway through a combination of public funding and assessments of families who would be serviced. People refusing to pay the assessment were threatened with forced sales of goods to make up the shortfall. Local residents were charged with ensuring proper maintenance; indeed, some of the wells later became known by the names of these overseers. By the 1700s, this had developed into a common practice in which a local group would petition the authorities to dig a public well or install a pump at a convenient place. In exchange, the costs of construction would be charged to the local residents.

Most New Yorkers relied on these wells and the "Collect" (the anglicized pronunciation of the Kalch-Hook) for free drinking water. During this period, however, urbanization continued and further industrial and population growth were clearly in store. Sanitation, an ever-present problem in British cities, was becoming unmanageable. Peter Kalm, a Swedish botanist visiting New York in 1748, observed, in a remark Rodney

Dangerfield would have loved, that the well water was so terrible horses from out of town refused to drink it.[4] The Collect, once the best source of drinking water on Manhattan, had become polluted by the tanneries and slaughterhouses on its banks. As the *Commercial Advertiser* reported in 1798:

> [The Collect] is a shocking hole, where all impure things center together and engender the worst of unwholesome productions; foul with excrement, frogspawn, and reptiles, that delicate pump is supplied. The water has grown worse manifestly within a few years. It is time to look out some other supply, and discontinue with use of a water growing less and less wholesome every day. . . . Can you bear to drink it on Sundays in the Summer time? It is so bad before Monday morning as to be very sickly and nauseating; and the larger the city grows the worse this evil will be. [5]

To those with an entrepreneurial spirit, the poor maintenance of the public wells and the increasingly disgusting state of the Collect posed not a problem but a business opportunity. People with means began to purchase water from springs outside of town and from deeper wells. The best known of these wells, located near the main settlement, became a popular source of water for tea and other kitchen uses. In a foreshadowing of bottled water's future marketing of brands, different water pumps were favored over others. Indeed, a cottage industry developed around a pump operated by the Hardenbrook family, popularly known as the Tea Water Pump, which apparently was the Perrier of its time. With attractive landscaped gardens around the well, the Tea Water Pump became a popular attraction.[6]

The real value, though, came in water distribution. Water sold from the pump and

other sources became generically known as Tea Water. "Tea Water Men" purchased water directly from pump owners and carted it throughout the city for sale in buckets and barrels at a healthy profit. By the middle of the eighteenth century, sale of Tea Water had become the best and dominant source of New York drinking water. As the *American Gazetteer* described at the time:

> Most of the people are supplied every day with fresh water, conveyed to their doors in casks, from a pump near the head of Queen street, which receives it from a spring almost a mile from the centre of the city. This well is about 20 feet deep and four feet diameter. The average quantity drawn daily from this remarkable well, is 110 hogheads of 130 gallons each.[7]

Twenty-four wholly separate distributers carted the water around the city. Purchasing a hogshead of water for six cents and selling bucketfuls at one cent a gallon, distributors had a profit margin of 2170 percent, an early example of just how much money could be made selling drinking water to individuals.[8]

The limitations of public wells and the Collect in providing clean water, growing dependence on Tea Water sales, and general concern over the availability of water to fight fires made clear the need for a serious rethinking of New York's water supply. Thus, in 1774, the city approved an ambitious plan for a steam engine–powered waterworks that would pump water throughout the city in aqueducts similar to those of Rome. To fund the public works, the city issued £11,400 of "Water Works Money." Notes were printed with the text "payable on DEMAND, by the MAYOR, ALDERMEN, and COMMONALTY of the City of *New-York*, at the Office of Chamberlain of the said City."[9]

CHAPTER 2—FIGURE 3

Water Works notes were the first paper money issued by an American city.

Construction commenced, but the timing could not have been worse. As the colonies descended into the Revolutionary War, the British occupied the city and promptly destroyed the waterworks construction. Following the Revolutionary War, the newly independent government stumbled along for more than fifteen years trying to solve the water supply issues. Plans were proposed for public waterworks and carefully studied, but none were funded. Water from the Tea Water Pump grew increasingly poor in quality and increasingly high in price. Nor did public wells provide a more attractive option.

New York was not alone in its troubles. The challenge of providing safe drinking water confronted all of the new nation's cities in the years following the Revolution. In 1793, a yellow fever epidemic shut down Philadelphia. Highly infectious, yellow fever was a death sentence in the eighteenth and nineteenth centuries, its victims suffering from fever, nausea, and jaundice from liver failure (hence the yellow appearance of the body and the name of the fever) before eventual death. For three months, the country's capital and busiest shipping port was paralyzed. Almost half of the city, more than twenty thousand people, fled to escape the contagion.[10] Imagine, for a moment, the hysteria that would ensue today if half of a major city's population hurriedly left to avoid a rampant disease.

Benjamin Franklin had already foreseen this danger. His last will and testament, read at the Philadelphia City Hall in 1790, had contained the following instructions of

how his £100,000 bequest to the city should be spent.

> And having considered that the covering of the ground-plot of the city with buildings and pavements, which carry off most of the rain, and prevents its soaking into the Earth and renewing and purifying the Springs, whence the water of wells must gradually grow worse, and in time be unfit for use, as I find has happened in all old cities, I recommend that at the end of the first hundred years, if not done before, the corporation of the city Employ a part of the hundred thousand pounds in bringing by pipes, the water of the Wissahickon Creek into the town, so as to supply the inhabitants, which I apprehend may be done without great difficulty, the level of that creek being much above that of the city and may be made higher by a dam.[11]

While the city fathers initially ignored this prescient advice, the yellow fever epidemic shocked them into action. Philadelphia's water system was completed in 1801, and its residents enjoyed reliable public water supply with streets washed down daily. Thanks to this bold public investment, Philadelphia avoided many of the terrible epidemics that afflicted other American cities in the following decades.

New York had been badly hit by yellow fever in 1795, and many blamed the disease on the city's foul water and fouler streets. With citizens and business leaders alike demanding action, the city council directed that the state legislature in Albany pass a bill providing the city with the power to tax goods sold at auction and use these proceeds to build the necessary water infrastructure. These were, by no coincidence, the same powers that the Philadelphia City Council had requested from the Pennsylvania state legislature in its push for civic improvement.[12]

However, affairs in Albany took a decidedly different turn in an alliance that would seem unthinkable years later. Assemblyman Aaron Burr teamed with Alexander Hamilton, recently retired as the nation's first Secretary of the Treasury, to transform the city's request for public financing powers into a private project. This is the same Aaron Burr who, nine years later as vice president, shot and killed Hamilton in a duel over insults supposedly made by Hamilton about Burr's candidacy for governor in New York.

CHAPTER 2—FIGURE 4

CHAPTER 2—FIGURE 5

In the portraits above, Burr is on the left and Hamilton, the face on the $10 bill, on the right.[13]

In an argument that would echo two centuries later through privatization debates in Cochabamba, Bolivia, and other cities around the world, Hamilton persuaded the New York state legislature that privatization was preferable to public financing because the service provider would be able to raise the necessary capital and save the city the politically difficult task of raising money through loans and taxes. Nor was this an unreasonable argument. While Philadelphia's waterworks had been provided by the municipality, this was the exception. Through the eighteenth and early nineteenth century, urban water projects were generally provided by private enterprise. Municipal authorities were often politically weak, and daunted by the high capital costs and maintenance expenses, city councils were much more comfortable relying on private capital to provide a public service. The corporation's shareholders might reap the profit,

but they also bore the risk.

Burr hurried a bill through in just three days. Authorized by the New York state legislature, the Manhattan Company, as the new organization would be called, was limited to $2 million in capital but granted broad-ranging powers. With the power of eminent domain, it was free to select whatever land it thought necessary for construction and any waters it deemed appropriate. If the parties could not agree on the proper compensation for private property taken by the company, a three-person body appointed by the New York Supreme Court would arbitrate. In stark contrast to other charters creating water companies during this period, the Manhattan Company had no obligation to repair city streets torn up placing pipes, provide free water for fighting fires, seek approval for water rates, or open its books for official inspection.[14] Indeed, the only constraint was that, within ten years of its creation, the Manhattan Company shall "furnish and continue a supply of pure and wholesome water sufficient for the use of all such citizens dwelling in the said city as shall agree to take it on the terms to be demanded by the said company." If this condition were not met, the company would lose its charter.[15]

This was a sweeping range of powers for a water company, but Aaron Burr had more than water supply on his mind. Near the end of the company's charter, a short paragraph revealed the real game afoot.

> And be it further enacted, That it shall and may be lawful for the said company to employ all such surplus capital as may belong or accrue to the said company in the purchase of public or other stock, or in any other monied transactions not inconsistent with the constitution and laws of this state or of the United States, for

the sole benefit of the said company.[16]

Burr didn't care about providing water. He wanted a bank charter, and one with far fewer constraints than other banks of the day. In short order, the company directed only 10 percent of the Manhattan Company's $2 million toward investments in waterworks. The other money was profitably invested in the banking business. The bank could not ignore water completely, for its existence depended upon satisfying the charter's requirement to furnish and supply "pure and wholesome water." Just how pure and wholesome, though, was a matter of dispute.

The lawmakers' assumption seems to have been that water would be piped in from the Bronx River, since the water sources on Manhattan Island had come to be regarded as undrinkable. But the Manhattan Company waterworks drew most of its water from the closer, cheaper, more revolting Collect. Doing the bare minimum to maintain its charter, the company laid only twenty-three miles of pipe in its first thirty-two years.[17] Centuries before the invention of water meters, the company charged customers based on the number of fireplaces. Houses with fewer than five fireplaces paid $5 annually, with a charge of $1.25 for each additional fireplace and a maximum charge of $20.[18] There were bitter complaints over the quality of the water. A letter in the *New York Evening Journal* angrily asserted:

> I have no doubt that one cause of the numerous stomach affections so common in this city is the impure, I may say poisonous nature of the pernicious Manhattan water which thousands of us daily and constantly use. It is true the unpalatableness of this abominable fluid prevents almost every person from using it as a beverage at the table, but you will know that all the cooking of a very large

> portion of this community is done through the agency of this common nuisance. Our tea and coffee are made of it, our bread is mixed with it, and our meat and vegetables are boiled in it. Our linen happily escapes the contamination of its touch, "for no two things hold more antipathy" than soap and this vile water.[19]

A letter in the *New York Commercial Advertiser* described the company as "the most outrageous insult ever offended to an afflicted city."[20] Despite unhappy water customers, the company defended its monopoly power over water provision and helped drive Tea Water pumps out of business. New Yorkers were thus forced to rely on the increasingly noxious Collect pond and local wells. People with money turned to imported soda water and well water mixed with liquor. As a historian of the era has described, "As for New Yorkers, drinking no more Tea Water and scant Manhattan, it was once again back to street wells and carted spring water. New York had entered the first American century with less good water than the Dutch had bequeathed to the English."[21]

Over time, this water company gave up all pretence and developed into the powerful Chase Manhattan Bank (now known as JP Morgan Chase), undoubtedly the first commercial bank that owes its origins to drinking water. In homage to its origins, the corporate logo of Chase Manhattan is a stylized cross section of a wooden water pipe. Ironically, Burr, the mastermind of the enterprise, ran into financial difficulties, sold his stock in the company, and was forced off the board in 1802.

By the first decades of the nineteenth century, the citizens of Philadelphia enjoyed ample supplies of clean water for drinking, cooking, battling fires, cleaning, and washing down the streets. Boston and Baltimore were in the process of building public waterworks based on Philadelphia's model. But following the debacle of the Manhattan

Company, New York did nothing. In 1828 a large fire caused extensive property damage, and in 1832 a severe cholera epidemic killed 3,500 people. Philadelphia, by contrast, had lost just 900 lives during the same scourge.[22] A water commission appointed by the New York City Council had to admit the obvious in its 1835 report: New York suffered by comparison with its rival City of Brotherly Love.

> No disagreeable odor assails the persons who pass through the streets of that city [Philadelphia]; everything calculated to annoy the senses is swept away by the running stream; but in New-York a person coming in the city from the pure air of the country, is compelled to hold his breath, or make use of some perfume to break off the disagreeable smell arising from the streets. . . . The only way we can account for this difference in the health of the two cities is, that Philadelphia is supplied with abundance of pure and wholesome water, not only for drinking and culinary purposes, but for bathing, and for washing the streets of the whole city, while New-York is entirely destitute of the means for effecting any of these purposes.[23]

The need for new infrastructure to store and distribute water was clear. The key question was how to pay for it—whether to rely on public or private financing, municipal funds or private capital. Philadelphia's experience certainly showed that public funding could be successful. London, however, was the capital of the world's greatest empire, and it relied on private means.

Through the Middle Ages, Londoners had gathered drinking water from local springs, wells, and the Thames River (the Romans never built aqueducts for London).[24] In the thirteenth century, a connection known as the Great Conduit was built from springs

near Tybburn to cisterns in the city and provided a source of clean drinking water, which apparently was sold by leasing official tankards to people for drawing water. The poor relied on the unsanitary and foul-smelling Thames, and some merchants even tried to charge for that. A 1417 city ordinance forbade owners of wharves and stairs on the Thames from charging for access to the river.[25]

During the sixteenth century, with the rise of England's first industrial revolution, the city was unwilling to spend money on public works and relied instead on private commerce for water supply.[26] As early as 1609, an open canal nearly forty miles north of London had been dug. It was known as the New River, and its management was granted to a private company. In 1721, the Chelsea Waterworks Company was founded, followed by six more private water companies over the next century. In all, eight companies provided more than twenty-eight million gallons of water from various sources in and around London. Supporters of privatization pointed to the might of the British Empire and urged New York to follow the privatization path of London.

Yet the same story could just as easily provide the opposite conclusion. Much of the water was taken from the River Thames, the receiving body for the city's sewers. Terrible cholera outbreaks were quite common but shrugged off as an unpleasant fact of urban living. The different water companies did not compete. Far from it. Following a model familiar to crime bosses, they realized far better profits by dividing the territory into separate monopolies where they each set their own rates as they saw fit.

In the end, chastened by the Manhattan Company debacle and envious of rival Philadelphia's success, New York's water commission strongly recommended public financing for construction. A permanent Board of Water Commissioners was created and

authorized to raise infrastructure capital and condemn land in order to supply water to the city. Surprising even today, the condemnation authority extended beyond the boundaries of the city, for the water source lay upstream of New York in the town of Croton. By 1838, condemnation of thirty-five acres of land in the Croton watershed had been completed.

The Croton Reservoir was a massive project, piping ninety-five million gallons daily through forty-one miles of pipe to a reservoir located in Central Park, lavishly decorated with Egyptian designs. The civic pride in the completion of the new water system is hard to imagine. The four days of inauguration ceremonies in October 1842 put a modern-day ticker-tape parade to shame. As Mayor Philip Hone wrote in his diary at the time, "Nothing is talked of or thought of in New York but Croton water; fountains, aqueducts, hydrants, and hose attract our attention and impede our progress through the streets. Political spouting has given place to water spouts, and the free current of water has diverted the attention of the people from the vexed questions of the confused state of the national currency."[27]

Commencing the festivities, amid one hundred firing cannons and ringing church bells, a five-mile parade snaked through the city. City Hall Park featured a fifty-foot fountain, and a hymn, "The Croton Ode," written specially for the occasion, was performed by the New York Sacred Music Society.[28]

Croton water, however, satisfied the city's needs for only a decade. The city then looked farther north, to the Catskills and Delaware watersheds some 125 miles from the city. In an even more impressive feat of engineering, more than six thousand miles of

tunnels, aqueducts, and distribution mains carried 1.2 billion gallons a day. In all, twenty-two upstate farming communities were moved in New York City's quest to secure freshwater, their towns drowned beneath the massive new reservoirs.[29]

Construction of the reservoir in Croton marked the end of significant private provision of drinking water for New Yorkers, displacing the Manhattan Company. Interestingly, however, it did not mark the end of water as an unpriced good, for with construction of the Croton Reservoir and the Croton Aqueduct came the installation in New York of so-called Croton Hydrants.[30] Following the lead of Philadelphia, these fire and street hydrants provided water free of charge and proved very popular.

The net result bore a fascinatingly strong resemblance to the Roman system of cross-subsidization from private pipes to *lacus* at the time of Caesar. Water from hydrants and fountains was free for the taking. Indeed, most New York homeowners felt no need to install piping or pay for the water service. It took several decades after introduction of the Croton Aqueduct for piped water to become dominant. The greatest attraction for piping water into the home was not drinking water but, rather, the convenience of domestic uses such as toilets (aptly named "water closets"), washing, and bathing.

{TEXTBREAK}

At the beginning of this chapter, Maude Barlow argued for access to drinking water as a human right granted by the state rather than a commodity furnished by markets. This remains a harshly fought controversy, with strident advocates on both sides of the issue. If our survey of drinking water management in different societies has shown anything, though, it is that markets and rights to water have often existed alongside one another.

A rights-based water management regime is clearly not a new idea. Not only have markets and rights to water coexisted, they have openly depended upon each other through cross-subsidization. In Rome, the private *vectigal* tax largely funded the *lacus* public wells. Though different in detail, a strikingly similar arrangement of private and public drinking water reappeared two millennia later in the form of the Croton Hydrants in New York and open hydrants in Philadelphia. From a historic vantage, the cases of Rome and New York show that markets can actually be used to *ensure* fulfillment of rights. Whether we can achieve the same result in the twenty-first century remains an open question, one that we will return to later in the book. First, though, we need to consider whether the water provided, by right or market, is safe to drink.

[1] collected rainwater in cisterns: Michael C. Finnegan, "New York City's Watershed Agreement: A Lesson in Sharing Responsibility," *Pace Environmental Law Review* 14

[2] cuts between Chambers and Canal: Charles H. Weidner, *Water for a City: A History of New York City's Problem from the Beginning to the Delaware System* (1974), 15.

[3] "many publique wells enclosed": As quoted in Gerard T. Koeppel, *Water for Gotham: A History* (Princeton: Princeton University Press, 2000), 21, citing Wayne Andrews, "A Glance at New York in 1697: The Travel Diary of Dr. Benjamin Bullivant," *New York Historical Society Quarterly* 40 (Jan. 1956), 55–73.

[4] the well water was so terrible: Koeppel, *Water for Gotham*, 27.

[5] "the worse this evil will be": Blake, *Water for the Cities*, 46.

[6] attractive landscaped gardens: Blake, *Water for the Cities*, 13.

[7] "110 hogheads of 130 gallons each": Blake, *Water for the Cities*, 13–14.

[8] how much money could be made: Ibid.

[9] to fund the public works: Images reprinted with permission from obsoletecurrency.blogspot.com.

[10] fled to escape the contagion: Blake, *Water for the Cities*, 5.

[11] "the corporation of the city Employ": Ibid., 3.

[12] powers that the Philadelphia City Council: Blake, *Water for the Cities*, 47.

[13] Burr is on the left and Hamilton: The portraits can be found at Wikimedia, http://commons.wikimedia.org/wiki/File:Aaron_Burr.jpg, http://commons.wikimedia.org/wiki/File:Hamilton_small.jpg.

[14] provide free water for fighting fires: Ibid., 50–51.

[15] the company would lose its charter: Ibid., 51.

[16] "any other monied transactions": As quoted in Blake, *Water for the Cities*, 50–51.

[17] the bare minimum to maintain its charter: Finnegan, "New York City's Watershed Agreement," 589.

[18] each additional fireplace: Blake, *Water for the Cities*, 59.

[19] "linen happily escapes the contamination": Ibid., 126.

[20] "the most outrageous insult": Ibid., 54.

[21] "less good water than the Dutch had bequeathed": Ibid., 101.

[22] a severe cholera epidemic: Ibid., 133.

[23] "washing the streets of the whole city": Ibid., 140.

[24] the Romans never built aqueducts for London: *London: The Greatest City: Medieval London*, at http://www.channel4.com/history/microsites/H/history/i-m/london2.html.

[25] owners of wharves and stairs: Text of the city ordinance is available at http://www.trytel.com/~tristan/towns/florilegium/community/cmfabr24.html.

[26] private commerce for water supply: "Water-Related Infrastructure in Medieval London," WaterHistory.org, http://www.waterhistory.org/histories/london/.

[27] "the confused state of the national currency": Blake, *Water for the Cities*, 165–166.

[28] a fifty-foot fountain: Elizabeth Royte, *Bottlemania* (New York: Bloomsbury, 2008), 97.

[29] their towns drowned: Finnegan, "New York City's Watershed Agreement," 14

[30] so-called Croton Hydrants: Koeppel, *Water for Gotham*, 279.

[32] the father of medicine: Milton A. Lessler, "Lead and Lead Poisoning from Antiquity to Modern Times," *Ohio Journal of Science* 88 (1988), 78.

[33] "water conducted through earthen pipes": John Scarborough, "The Myth of Lead Poisoning among the Romans: An Essay Review," *Journal of the History of Medicine* 39 (1984), 469.

[34] "you could no more turn off": Hodge, "Vitruvius, Lead Pipes," 486.

[35] "hardens into a crust": "Lead Poisoning and Rome," http://penelope.uchicago.edu/~grout/encyclopaedia_romana/wine/leadpoisoning.html.

[36] by boiling the mixture: Nriagu, "Saturnine gout," 660.

[37] a diet with *sapa*: A. Mackie, A. Townshend, and H. A. Waldron, "Lead concentrations in bones from Roman York," *Journal of Archaeological Science* 2 (1975), 235.